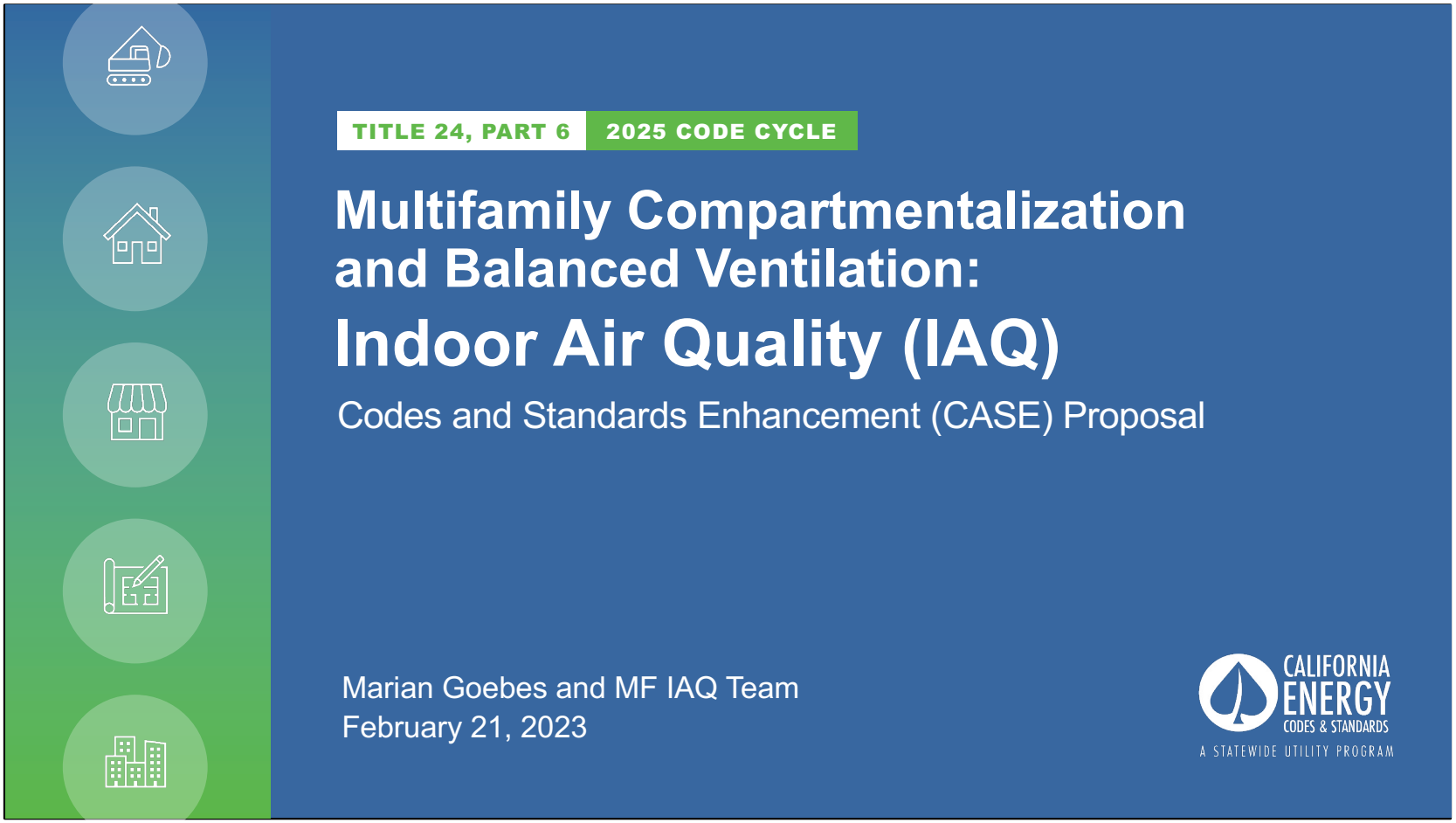


We have an MF IAQ measure to ensure that IAQ is protected, and hopefully improved, due to requirements in the energy code.

Why Do We Need a Multifamily IAQ Measure?

Protect public health by providing a high level of Indoor Air Quality (IAQ) while other Title 24, Part 6 requirements call for homes to be built with improved insulation and lower air leakage

- Indoor pollutants are correlated with exacerbation of respiratory problems including asthma, which particularly affect children
- Other indoor pollutants (e.g., benzene) linked to cancer

IAQ Strategy	Addressed in Proposed Measure?
Source Control: Reduce emissions or keep pollutants out	Yes (Compartmentalization)
Local exhaust: Remove pollutants	No (Addressed in 2022 Title 24, Part 6)
Dilution: Bring in outdoor air	Yes (Balanced or supply-only ventilation)

- Multifamily units have additional risks because greater occupant density and smaller spaces, often in areas with high outdoor pollution, and pollution from neighboring units poses a risk
- Both components of the mandatory measure (balanced or supply-only ventilation, and compartmentalization) each have important IAQ benefits, and work hand-in-hand

In addition, the proposed measure saves energy and promotes comfort.

Background

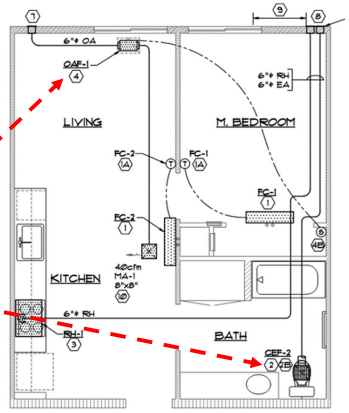
- 2022 Code Requirements
- Code Change Proposal
- Rationale, Context and History

Current Code Requirements

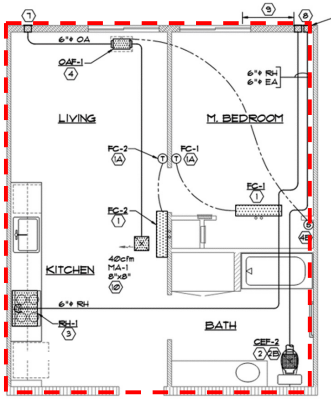
Existing Requirements in 2022 Title 24, Part 6

- Mandatory (since 2019): New construction multifamily units must have either:
  - Balanced ventilation, or
  - Meet a compartmentalization requirement of 0.3 cfm50/sf
- Prescriptive (since 2022): If choosing balanced, must use heat or energy recovery ventilator (H/ERV) in Climate Zones 1, 2, 11-16

Balanced ventilation example:
- Continuous supply air, and
- Continuous exhaust



Compartmentalization example:
Air sealing around dwelling unit enclosure



Intermittent exhaust flows exempted.

Terminology:

- Balanced ventilation: Dwelling unit has outdoor air supply and exhaust, at same airflow rate. Intermittent exhaust ignored.
- Compartmentalization: Air seal each dwelling unit with neighboring units and corridors (IAQ: reduce pollutant transfer) and exterior (energy). Measured with blower door test on sample of units, at 50 Pascals

Proposed Code Change

- **Mandatory requirement:** New construction multifamily units must have both:
  - Balanced ventilation or supply-only ventilation, and
  - Meet a compartmentalization requirement of ≤0.3 cfm50/sf
  - **Change: Went from "or" to "and"**. Also allowing supply-only ventilation (not just balanced)
- **Prescriptive HRV requirement**: New construction multifamily units in Climate Zones 1, 2 and 11-16 must use balanced ventilation with heat or energy recovery ventilator (H/ERV).
  - **Change: Went from "Use H/ERV if using balanced ventilation" to "Use H/ERV".** Climate zones unchanged
- **Compliance Option for tighter units:** Under performance approach, additional compliance credit will be made available for tightening further to ≤0.23 cfm50/sf
  - Change: New option

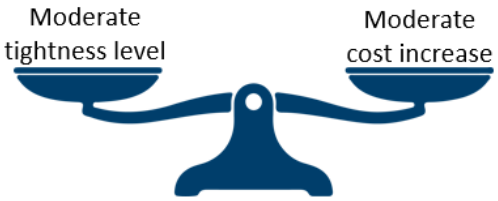
No changes proposed for additions or alterations.

On prescriptive measure: because market research indicates most units are already doing balanced ventilation, and H/ERV is required if using balanced, the proposed requirement isn't much of a change compared to current requirements
Because sections 180.1 (Additions) and 180.2 (Alterations) reference new construction requirements, there are proposed revisions to the language in 180.1 and 180.2 so their requirements remain the same

Proposed Code Change Rationale and Details

- Ventilation strategy details:
  - **Why:** Balanced or supply-only ventilation ensures there is a dedicated source of outdoor air
  - Like balanced ventilation, supply-only ventilation also provides dedicated source of outdoor air
  - Only regulates whole dwelling ventilation. Dwelling units must still have local exhaust: kitchen, bathroom, dryer.

- Compartmentalization details:
  - **Why:** Reduces pollutant transfer from neighboring units and infiltration of outdoor particulate matter (PM)
  - Requiring ≤0.3 cfm50/sf strikes a balance: moderate tightness level at moderate cost increase
  - Sampling is still allowed for HERS Rater's verification (blower door test)
- Both work together by reducing pollutant infiltration (compartmentalization) but ensuring adequate outdoor air (ventilation strategy)



Supply-only ventilation also uses less energy: one fan instead of two

Proposed Code Change: Context and History

- Both balanced ventilation and compartmentalization (≤0.3 cfm50/sf) have been available compliance paths since 2019 Title 24 part 6
- ASHRAE Standard 62.2-2022 requires balanced ventilation or supply-only ventilation for new construction multifamily units (exception for garden-style)
- Many codes, standards, and programs require compartmentalization at 0.3 cfm50/sf or tighter

Looser

Tighter

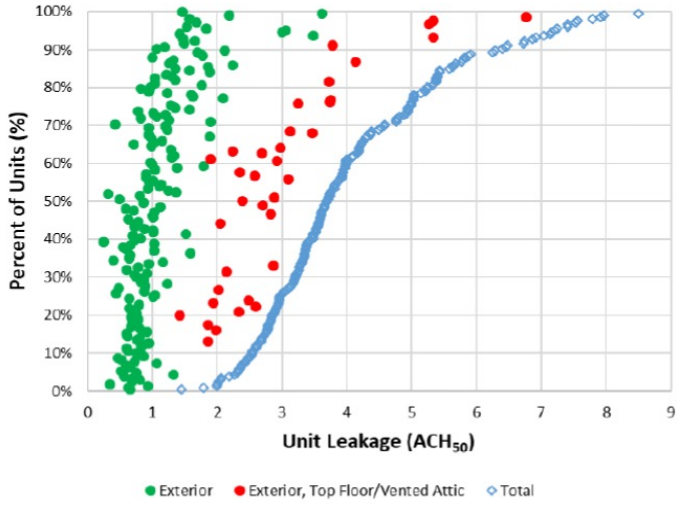
Code/Program	Air Sealing Requirement
IECC-2021 Code	≤0.3 cfm50/sf or whole building leakage test
2021 Washington State Energy Code	≤0.25 cfm50/sf for garden-style units and a whole building leakage test for common-entry buildings
LEED for Homes Midrise Program	≤0.23 cfm50/sf (or up to 0.3 for small units)
ASHRAE 62.2-2022 Standard	≤0.2 cfm50/sf

From 2018-2022, there are 186 LEED certified multifamily projects in California

Proposed Code Change: Context and History

Justification for balanced or supply-only ventilation:

- In a multifamily dwelling unit, an exhaust-only approach will bring in a mix of outside air (good!) and air from neighboring units (not good for IAQ)
- From field measurements, Center for Energy and Environment (CEE, 2020) found on average ~30% of a dwelling unit's leakage came from exterior, with huge variability by unit
- UC Davis study (not yet published) found exhaust-only ventilation provides variable ventilation rates, with some units under-ventilated



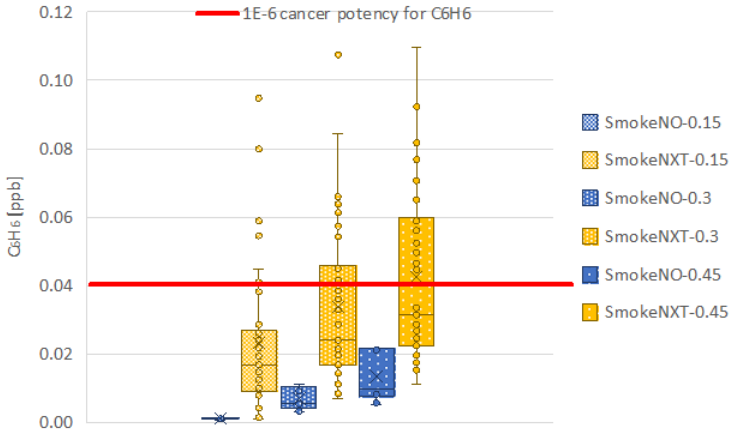
Cumulative Distribution of Unit Total Leakage (blue dots) and Exterior leakage (green and red dots)

Source for leakage plot: Center for Energy and Environment, "Energy Code Field Studies: Low-Rise Multifamily Air Leakage Testing". 2020

Proposed Code Change: Compartmentalization

Justification for compartmentalization:

- **IAQ benefits**
  - Reduced pollutant transfer between units
    - Reduces cooking pollution (PM2.5, NO2, formaldehyde, benzene, etc.), smoking (cigarettes or cannabis), and odors
  - Reduced PM2.5 infiltration from exterior
- **Comfort (noise reduction) improvements**
  - Multifamily projects often located in noisy, urban areas, and quiet environment important for sleep and mental health
- **Energy savings** from reduced leakage through exterior envelope



Concentration of benzene (C_6H_6) for units next to a smoker (SmokeNXT) and not next to a smoker (SmokeNO) at different compartmentalization levels: 0.15, 0.3, and 0.45 cfm50/sf (UC Davis – not yet published)

On PM2.5 reduction from exterior: a study by LBNL of a single-family home found that the envelope acted similar to a MERV 13 filter, but the envelope was 5 ACH50, similar to ~0.2 to 0.25 cfm50/sf.

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

First for Ventilation Strategy, then for Compartmentalization

Market Overview: Ventilation Strategy

Based on interviews with 12 multifamily practitioners and plan reviews of 6 multifamily buildings:

Dwelling unit ventilation strategy	Common Approach(es)	Estimate under 2019 Title 24 Part 6
Exhaust-only	Bathroom fan runs continuously. Bathroom fan may have “boost” mode for local exhaust	15%
Supply-only	• Through-wall (horizontally ducted) in-line fan provides outside air to each unit, or • Rooftop dedicated outdoor air system (DOAS) provides outside air to each unit	0%
Balanced	• One of the supply-only approaches with continuous bathroom exhaust, or • Individual or central heat or energy recovery ventilators (HRVs/ ERVs)	85%

Reminder we're only talking about dwelling unit ventilation strategy, not local exhaust unless the local exhaust is part of dwelling unit ventilation strategy

Market Overview and Analysis: Compartmentalization

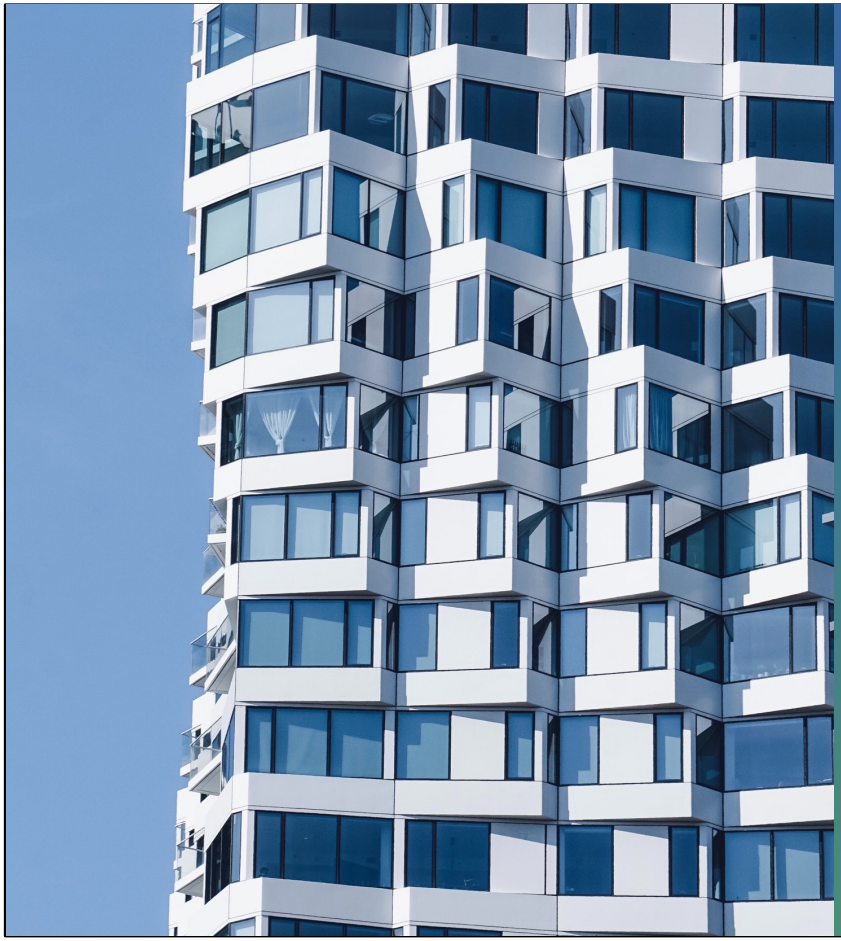
Market Trends

- Roughly one-third of market with compartmentalization experience
- Of 12 interviewees, two-thirds did not try compartmentalization. One-third have met a compartmentalization target, primarily for LEED. *(This may increase as they build more Title 24-2019 projects.)*
- CalCERTS data for low-rise MF shows 30% are reporting a compartmentalization value.
  - 50th percentile at 0.24 cfm50/sf

Compartmentalization results (cfm50/sf) for 2019 Title 24 Part 6 Low-rise MF Units from CalCERTS				
25th percentile	50th percentile	75th percentile	99th percentile	100th percentile
0.19	0.24	0.27	0.30	0.51

- Remaining two-thirds (63%) have not tried to meet a compartmentalization target.

- Interviewees noted they are just starting to design and build Title 24-2019 projects, so compartmentalization may become more common



Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations: Ventilation Strategy

Technical Considerations

- Technically feasible given prevalence of balanced ventilation in the market
- Multiple strategies and technologies available

Technical Barriers and Potential Solutions

- Regular replacement of filter
  - *Choose central (e.g., rooftop) systems for supply-air to centralize maintenance*
- Tempering ventilation air
  - *Include heat recovery, or*
  - *Deliver air in uninhabited part of unit (hallway, entrance, above fridge)*

Technical Considerations: Compartmentalization

Interviewees that have met a compartmentalization target reported ≤0.3 cfm50/sf is very feasible. Feedback in interviews:

- 0.3 cfm50/sf primarily requires sealing big (e.g., plumbing) penetrations, but sealing below 0.25 cfm50/sf takes changes to specifications.
- "0.3 is not a huge burden to project teams, while also ensuring you don't have a massive problem in the envelope."
- "0.3 is easy. 0.23 could be done."
- Two market actors (out of four) reported challenges meeting 0.23 cfm50/sf

Technical Considerations: Compartmentalization

Technical Barriers and Potential Solutions

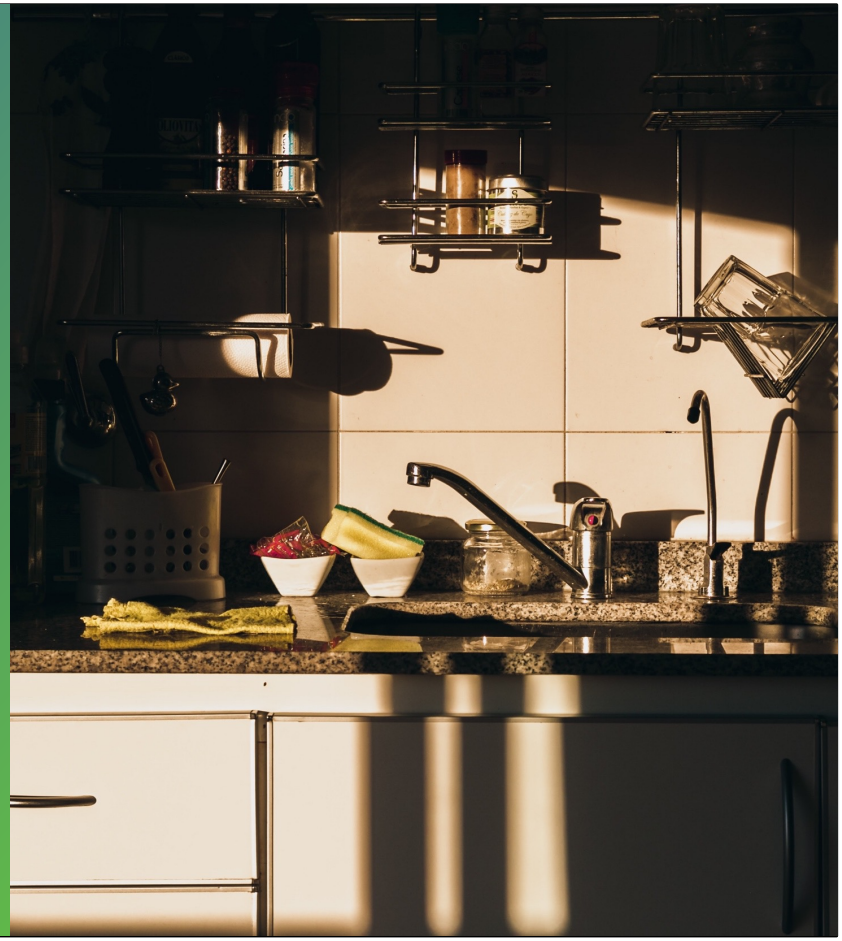
- Achieved through more careful labor practices. Not a widget
  - → *Solution: Architect identifies dwelling unit air barrier and sealing details, project team increases coordination to execute*
- Compartmentalization testing done at end of project
  - → *Solution: Test mock-up unit (further in construction than other units) to check progress and identify improvement opportunities*
- Compartmentalization more challenging for metal-framed construction due to holes in studs
  - → *Solution: More attention to detail is needed for compartmentalizing metal-framed buildings*

Example of a fog puffer for finding leaks
(Source: The Energy Conservatory, https://store.energyconservatory.com/tec-fog-puffer.html.)

Energy and Cost Impacts Per Dwelling Unit

Methodology and Assumptions

- Mandatory Measure for Balanced or Supply Ventilation, and Compartmentalization
  - Energy Savings Methodology and Results
  - Cost Impacts Methodology and Results
- Prescriptive HRV Measure
  - Energy Savings Methodology and Results
  - Cost Impacts Methodology and Results



Methodology for Energy Impacts: Mandatory Measure

The mandatory changes are proposed for IAQ reasons. Cost effectiveness is not required but considered.

Overview of method:

1. Estimated impact of compartmentalization on exterior air leakage.
    - Base case: Followed assumption of CBECC Alternative Calculation Method (ACM) Reference Manual assumption of 7 ACH50 from exterior.
    - Proposed case: Based on a field study that measured fraction of dwelling unit leakage from the exterior, we assumed compartmentalization reduces exterior leakage to 2.3 - 3.2 ACH50 (depending on prototype)
2. Conducted energy simulations of different possible compliance scenarios, because the base case (existing code) and proposed case allow different compliance options
3. Developed a weighted average of savings from the different scenarios based on market research

Methodology for Energy Impacts: Mandatory Measure

Case	Weighting of Scenarios for Energy and Cost Impacts
Base	85% balanced (with HRV in CZs 1, 2, 11-16) and 7 ACH50 (no compartmentalization) 15% exhaust only and 2.3 to 3.2 ACH50 (with compartmentalization)
Proposed for Climate Zones 1, 2, 11-16	100% balanced with HRV, and 2.3 to 3.2 ACH50
Proposed for Climate Zones 3-10	85% balanced and 2.3 to 3.2 ACH50 15% supply-only and 2.3 to 3.2 ACH50

Leakage reduction due to compartmentalization is 2.4- 3.2 ACH50 depending on prototype

Methodology for Costs: Mandatory Measure

Overview of method:

1. **Averaged incremental costs of different ventilation strategies** using two mechanical contractors' estimates
   - Compared to exhaust-only: Approximately **$1,200** for balanced without HRV, and **$1,700** for HRV, plus replacement of supply fans or HRV at Year 15 and filter replacements.

2. **Averaged cost to compartmentalize to 0.3 cfm50/sf** using three contractors' and raters' estimates
   - Approximately **$465 to $567** per dwelling unit, plus touch-up (~$100) at Year 15
   - Compartmentalizing to 0.23 cfm50/sf is ~$900+, so we did not propose this as the requirement

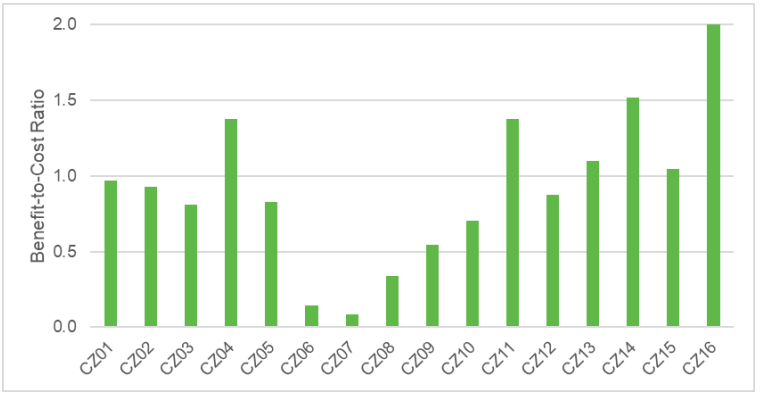
3. **Used the same weighted average of scenarios** that we used for energy analysis.
   - Generally assumed 85% add compartmentalization, and 15% change ventilation strategy
   - **Total 30-year incremental cost ~$890,** varying ($858 to $1018) by climate zone and prototype

Unit sizes ranged from 540 to 1410 sf, and on average ~800 sf. Costs were higher for larger units since more ductwork, and varied a bit by prototype, but for simplicity just showing averages. CASE report has results by building type.
Total incremental cost includes first cost, maintenance, and replacement costs in 2026 $

Benefit-to-Cost Estimates Per Dwelling Unit: Mandatory Measure

Energy savings and cost estimates for mandatory measure: Balanced / supply ventilation + compartmentalization:

- Proposal is cost effective in some climate zones, not in others. **Because the rationale is IAQ, it does not need to be cost effective**
- Positive energy savings in all climate zones (CZs). Per dwelling unit Lifecycle System Cost (LSC) range from $84 to $1,900
- Variation in energy savings (and thus cost effectiveness), because compartmentalization leads to greater savings in CZs with higher heating and cooling needs



Benefit-to-Cost Ratio of Mandatory Measure by Climate Zone, Weighted Across all Multifamily Prototypes, over 30 Years

Benefit-to-cost ratio >=1 is cost effective

Methodology for Energy and Cost Impacts: Prescriptive HRV Measure

Builds off the 2022-Title 24 Part 6 Prescriptive measure: If a multifamily unit uses balanced ventilation in CZs 1, 2, or 11-16, it must incorporate a H/ERV.

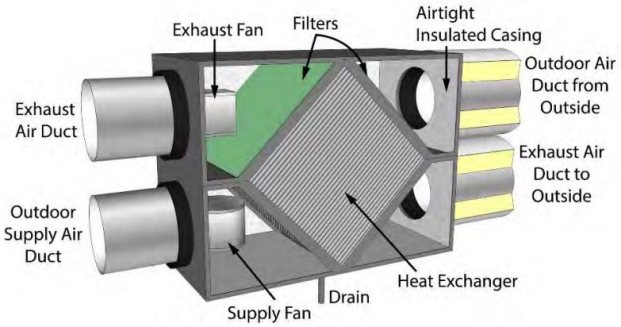
Cost effectiveness is required, because the measure is proposed for energy savings.

Energy savings methodology:

- Baseline: A mix of balanced without heat recovery (85%), and supply-only (15%)
- Proposed: Balanced with HRV

Cost savings methodology: Based on two mechanical contractors' estimates:

- Assumed $460 incremental cost for HRV compared to supply-only or balanced without heat recovery, plus replacement at Year 15
- Analyzed cost effectiveness in all climate zones and across all prototypes.



Components of a Heat Recovery Ventilator (HRV)
(Source: City of Vancouver, https://vancouver.ca/files/cov/heat-recovery-ventilation-guide-for-houses.pdf.*)*

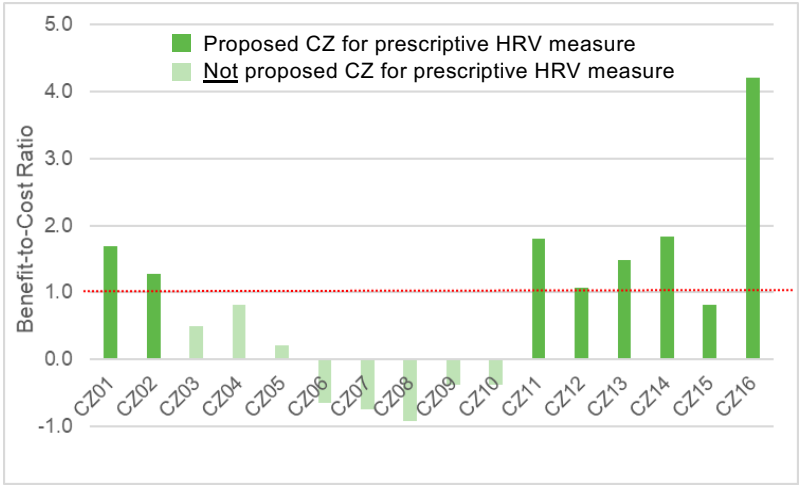
Assumed no difference in $ btw supply-only and balanced without heat recovery, since you need local bathroom exhaust regardless. It did make a difference in energy savings, b/c HRV produces less energy savings compared to supply-only b/c you only run 1 fan in that scenario.

Cost-Effectiveness Estimates: Prescriptive HRV Measure

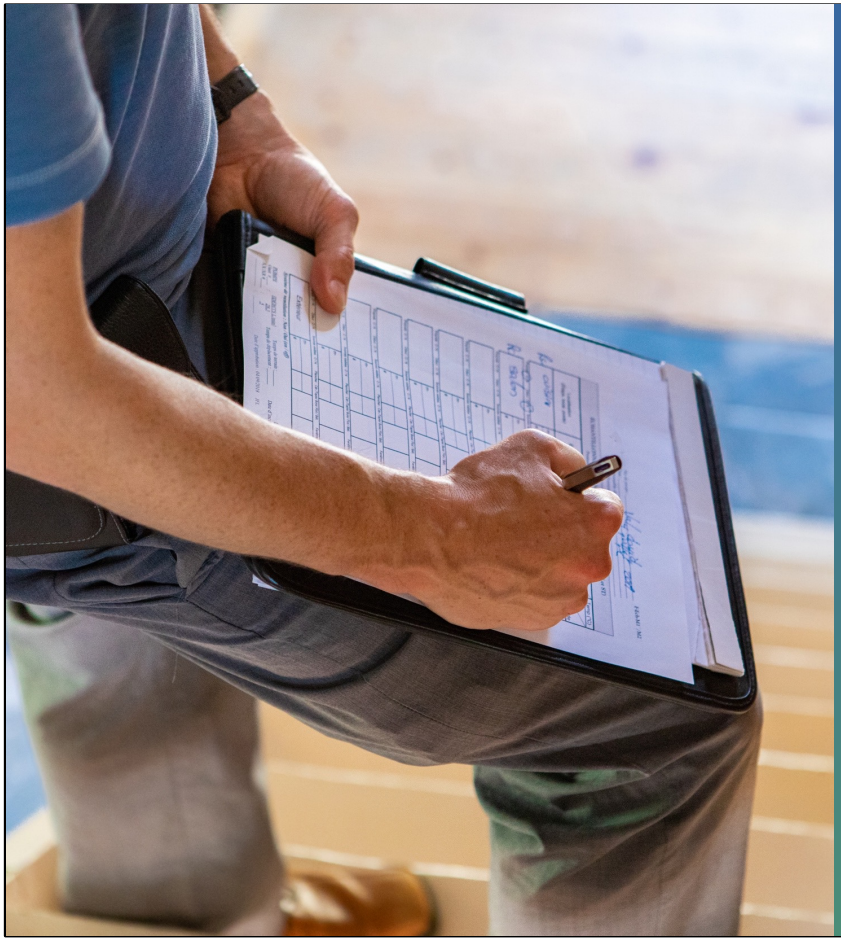
Energy savings and cost estimates for prescriptive measure: Heat or Energy Recovery Ventilation (H/ERV) in Climate Zones 1, 2, 11-16:

Proposal is cost effective in all proposed climate zones, except CZ 15.

- Not cost effective in other climate zones.
- Because the rationale is energy savings, it must be cost effective in all proposed climate zones
- If CZ 15 is not cost effective in final analysis, CZ 15 will be dropped



Benefit-to-Cost Ratio of Prescriptive Measure by Climate Zone, Weighted Across all Multifamily Prototypes, over 30 Years

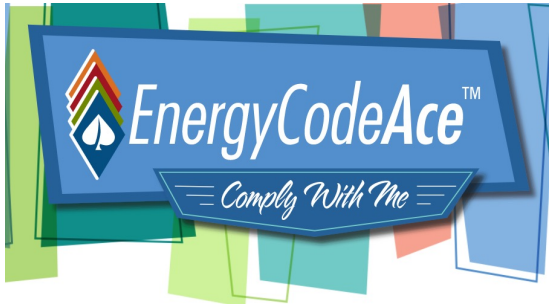


Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection
- Revisions to Compliance Software

Compliance and Verification Overview

- While this proposal is one measure package, the compliance and verification procedures are independent for ventilation strategy and compartmentalization, so the following slides show compliance and verification for each separately
- Because 2022 (and 2019) Title 24 Part 6 requires either balanced ventilation or compartmentalization, the Energy Standards already have compliance and verification procedures and forms for both
  - No major changes
  - Both must be completed, and exhaust-only ventilation will no longer be allowed
- Because most multifamily projects are already doing balanced ventilation, the change for most of the market will be compliance and verification of compartmentalization



Energy Code Ace provides tools and training for compliance

Energy Code Ace provides tools and training for compliance

Compliance and Verification: Ventilation Strategy

1. Design Phase

- Mechanical designer identifies a whole dwelling unit ventilation strategy (supply-only or balanced), and whether an H/ERV will be incorporated
- The mechanical designer locates equipment, including duct routing and duct exterior terminations, and specifies fan airflow rates and controls

2. Permit Application Phase

- Design team applies for a building permit with design drawings, specifications, and certificate of compliance forms
- Plan checker would verify the ventilation strategy, verifying that the dwelling units have balanced or supply-only ventilation

Compliance and Verification: Ventilation Strategy

3. Construction Phase

- Mechanical contractor installs the ventilation systems, and conducts commissioning and start up
- The general or mechanical contractor completes certificate of installation forms

4. Inspection Phase

- Inspector verifies the type of ventilation system in the permit (balanced or supply-only) is installed.
- HERS rater field verifies the ventilation airflow rate per RA3.7.4.1 and NA2.2 for a sample of units and confirms that the installation is consistent with the forms

Compliance and Verification: Compartmentalization

1. **Design Phase**
   The architect specifies the compartmentalization level (≤0.3 for mandatory, ≤0.23 for compliance option), identifies the dwelling unit air barrier on plans, and specifies sealing

2. **Permit Application Phase**
   - The design team submits plans and specifications, including certificate of compliance forms, to the enforcement agency
   - Plan checker ensures that the design documents identify the target compartmentalization level

Compliance and Verification: Compartmentalization

3. Construction Phase

- General contractor works with subcontractors to execute air sealing at each construction stage
- General contractor completes certificate of installation forms

4. Inspection Phase

- HERS rater conducts blower door testing according to RA3.8 and NA 2.3 for a sample of dwelling units
- HERS rater completes certificate of verification forms

Blower door test set-up

RA 3.8 Field Verification and Diagnostic Testing of Air Leakage of Building Enclosures and Dwelling Unit Enclosures

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

Draft code language available for review in the resources tab and downloadable: Measure Summary Documents .

Provide feedback to Marian Goebes and cc info@title24stakeholders.com by **March 7, 2023**.

What general feedback do you have for the proposed code change?

Discussion and Next Steps

We want to hear from you!

- POLL QUESTION NEXT SLIDE:
  - Do you think this proposal strikes the right balance when considering IAQ needs, energy savings, and cost impacts? Provide **any last comments or feedback** now, verbally, or in the Questions Pane.
- More information on pre-rulemaking for the 2025 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Comments on this measure are due by March 7rd, 2023. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

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Thank you...

- **Stakeholders for your attention**
- **Interviewees for input**
- **MF IAQ Teammates:** Rupam Singla, Eric Martin, Antonea Frasier, Grant Marr, Annie Huang, Don MacOdrum, Melanie Hamilton, Frontier Energy

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM